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XXXV. *An Extract of a Letter from Dr.* Nooth *to Dr.* Franklin, *F. R. S. on ſome Improvements in the Electrical Machine.*

Read June 24, 1773.

IT muſt undoubtedly appear extraordinary, that, in the preſent age, when the ſtudy of electricity is become ſo general, and the advances that have been made in the ſcience are ſo very conſiderable, I ſhould attempt to recall your attention to the ſtructure of the electrical machine. But I believe it muſt be allowed, that, notwithſtanding the remarkable progreſs that has of late been made in electrical purſuits, the machine ſtill remained the moſt imperfect part of the apparatus. The conſtruction of it has been in general left to the workman, who has ſeldom been in a capacity of making thoſe improvements in it, which it certainly admits of.

The ſubject, however, ſeems well worth the attention of the electricians themſelves; as a knowledge of the means of correcting the capricious ſtate of their machines will enable them to purſue

their electrical inquiries with more certainty, ſucceſs, and ſatisfaction.

A proſpect of diſcovering the cauſe of the common uncertainty in the action of electrical machines, induced me, ſome months ſince, to make ſome obſervations on the appearances produced by a machine in motion. Being well convinced, that the electric fire, which we receive from a machine, is derived from the cuſhion, and from ſuch parts as communicate with it, I firſt attended to the effects which the glaſs and rubber had on each other.

My inquiries, however, were not directed towards an inveſtigation of the cauſe of that accumulation of electric matter, in conſequence of the friction of the glaſs on the rubber, as I looked on that circumſtance as a ſecret in nature, no leſs impenetrable than gravitation itſelf; but I endeavoured to find out the beſt method of increaſing the excitation of a glaſs, and of taking from it that fire for electrical purpoſes which might be collected on its ſurface.

It is evident, that the electric matter is excited in the inſtant that the glaſs paſſes over the rubber, and that it becomes ſenſible to us by its adhering to the revolving ſurface of the glaſs. It likewiſe appeared to me highly probable, that the quantity of fire, which we find on the glaſs in motion, is not the whole of that which is excited by the paſſage of the glaſs on the rubber. The luminous appearance in the angles between the glaſs and rubber, and which is extremely diſtinct in a dark room, rendered it next to certain, that a part of the excited electric fluid returns immediately to the cuſhion

cuſhion without performing a revolution with the glaſs; and that, of courſe, a circulation of the fire is thus kept up in the ſubſtance of the cuſhion in the common method of conſtructing the machines.

To be certainly convinced of this, I attempted to make the paſſage of the fire from the glaſs to the anterior part of the cuſhion, or to that part which correſponds with the aſcending ſide of the cylinder, demonſtrable, by placing a piece of ſilk between the glaſs and cuſhion. This ſilk was larger than the cuſhion; and part of it was allowed to adhere, by the attraction of the electric fire, to the aſcending part of the cylinder. My view in doing this was to cut off, in that part, the immediate communication between the excited glaſs and cuſhion, and by that means render the circulation of electric matter viſible, which I ſuſpected to take place in the machine; as it was thus forced to turn over the looſe edge of the ſilk before it could return to the cuſhion. The event anſwered my expectation; and I then perceived, that the greateſt part of the excited fluid was commonly re-abſorbed by the fore-part of the cuſhion without becoming ſenſible on the ſuperior part of the glaſs.

Having thus verified my ſuppoſition by actual experiments with ſilken flaps of different ſizes, I endeavoured to diſcover a method of preventing that circulation of the electric fluid, and, if poſſible, of obliging the whole, or the greater part of it, that is once excited, to make the revolution with the glaſs. This, indeed, the ſilk, when of conſiderable breadth, in ſome meaſure effected; but I thought that this obſtruction to the immediate re-

turn of the fire might be rendered more complete by increaſing the thickneſs of the ſilk, or by applying to it ſome nonconducting ſubſtance, that might confine the excited fluid more perfectly to the ſurface of the revolving cylinder.

Bees-wax being a nonconducting ſubſtance eaſily procured, I rubbed the ſilken flap with it, and found, as I expected, that the return of the fire to the cuſhion at the anterior part of the machine was by that means much diminiſhed, and conſequently the excitation of the glaſs was apparently increaſed. The addition, however, of more ſilk was ſtill more effectual in confining the fire to the glaſs; and when it was employed ten or twelve times doubled, it ſeemed to deny any paſſage from the glaſs to the cuſhion.

As I thus diſcovered the method of remedying the common defect in the conſtruction of the anterior part of the cuſhion, I next attended to that part which correſponds with the deſcending ſide of the cylinder. Being convinced that this part of the rubber was alone concerned in the excitation, I imagined that the reverſe of what was neceſſary anteriorly ſhould be adopted in the ſtructure of the poſterior part; that, inſtead of placing nonconducting ſubſtances between the glaſs and cuſhion, we ſhould here make the afflux of the electric matter as great as poſſible, by the application of the moſt perfectly conducting bodies. Confining therefore the amalgam to that place where the glaſs firſt comes in contact with the rubber, I placed ſome tinfoil cloſe to the amalgam, and, bending it back, ſecured it to the metallic plate below the cuſhion. By this means

means the electric matter found an eaſy acceſs to the place of excitation; and the effect of the machine was thereby incredibly increaſed. A piece of leather, covered with amalgam, and fixed to the poſterior part of the rubber, in ſuch a manner as to allow about an inch of it to paſs under the cylinder, anſwered every purpoſe of the tinfoil; and, as it was not liable to be corroded by the mercury, like tinfoil, it was on that account much preferable.

From the above experiments it was apparent that the excitation was altogether performed by the poſterior portion of the cuſhion; and that the anterior part, when made of conducting ſubſtances, re-abſorbs the greater quantity of the excited matter. In the ſtructure therefore of electrical machines, we ſhould always have a free electric communication behind, to facilitate the excitation; and the moſt perfectly nonconducting ſubſtances before, to prevent the re-abſorption. To anſwer theſe intentions, it will perhaps be adviſeable to make the cuſhion of ſilk, ſtuffed with hair, and to lay ſome metallic conductor round the poſterior part, that a free acceſs might be allowed to the electric matter coming to the place of excitation from the inferior part of the machine. Cuſhions, made in this manner, and then covered with ſilk ten or twelve times doubled, are much more powerfully excitant than any others that I have yet tried. Various other methods, however, may be purſued in the conſtruction of the rubber; but it ſhould be an invariable rule, to place nonconducting bodies before, and conducting ſubſtances behind, the cylinder. From the preceding principles, it follows, that the ſupport

to the rubber ſhould likewiſe have its conducting and nonconducting ſide. For this purpoſe, it may be neceſſary to employ baked wood, and to cover the poſterior half with tinfoil. The place of excitation will be thus ſufficiently ſupplied with electric matter; and the cylinder will not be robbed of a part of the excited fire, before that fire has made a revolution with the glaſs.

By attending to the place where the excitation is effected, it muſt appear evident, that the amalgam is only to be laid on the poſterior part of the cuſhion; its preſence, indeed, would be uſeleſs, if not injurious, in any other ſituation. It will, however, be found ſomewhat difficult to confine the pure amalgam to the poſterior part of the rubber; but if it is mixed with a little hair-powder and pomatum, it pretty perfectly keeps its place. The ſtrewing the amalgam thus prepared on the glaſs, as it revolves, is perhaps the beſt method of applying it; as, by that means, it is in a great meaſure prevented from paſſing on to the nonconducting ſubſtances that are placed before. Should any of the amalgam be carried forward by the revolution of the glaſs, it ſhould be carefully removed. The neceſſity of keeping that part free from conducting bodies cannot be too much inſiſted on; and, when freſh amalgam is applied as before mentioned to the proper part of the rubber, the flap ſhould be held down during half a dozen turns of the machine, leſt it might collect ſome of the amalgam before it is properly fixed. It is a probable conjecture, that, when the flap of ſilk is covered with amalgam, part of the amalgam, which is not immediately ſubſervient to the excitation,

tion, acts as a conductor in reſtoring the fire again to the cuſhion; and that thus, by an improper diſpoſition of it, we ſuppreſs, inſtead of increaſing, the quantity of the excited matter.

In ſhort, when an electrician attends to the preceding principles in the conſtruction of his rubber, and to the proper diſpoſition of the amalgam, he has nothing to fear from the humidity of the atmoſphere, as his machine will work equally well in all kinds of weather. The reſt of the electrical apparatus may be made according to the directions that have been given by the different electrical writers. Each has had his favourite machine; and, perhaps, no one has been yet contrived that has not had its peculiar advantages.